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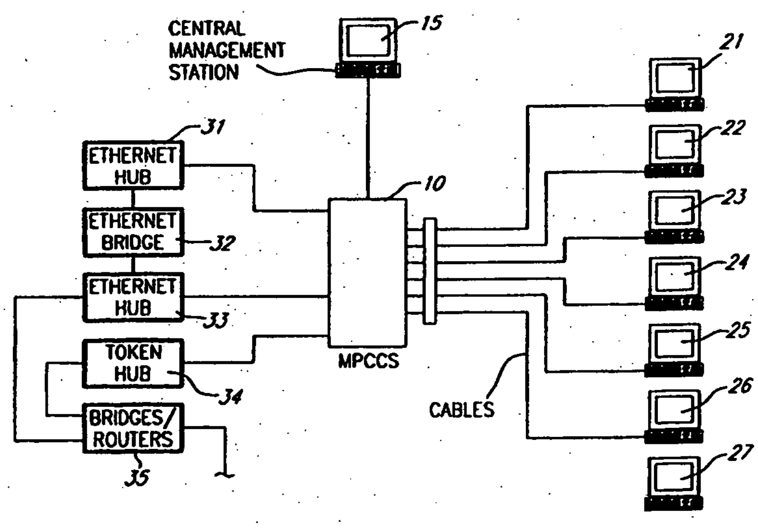

(57) Abstract

The present invention relates to a cross-connect switch which allows different protocols to be used. The switch is made up of two cross point modules, one for transmission and one for reception. I/O blocks corresponding to each station or network interface are connected to the cross point modules. Each I/O block includes four differential pairs. The I/O block permits selective activation for transmission or reception of any of the four pairs. In addition, half duplex control logic is used to implement protocols using a single differential pair for both transmission and reception. Also a token ring interface is included on the I/O blocks in order to allow detection and generation of phantom DC currents necessary for operation with token rings.

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NETWORK INCLUDING MULTI-PROTOCOL CROSS-CONNECT SWITCH

Field of the Invention

The present invention relates to cross-connect switches for use in data networks. In particular, it relates to a cross-connect switch which can connect computers to various networks using different protocols.

Discussion of the Related Art

Computer networks have expanded greatly in terms of numbers of computers connected to a network and the types of networks which exist. In fact, a single computer may be part of several networks with different capabilities. Networks also have various numbers of computers, from work groups, to local area networks, wide area networks, and global networks, such as the Internet and world wide web. With so many types of networks created by various companies, different protocols are used for communications. Examples of these protocols include RS 232, Ethernet, Fast Ethernet, Token Rings, and ISDN. These protocols not only require special communications software, but also have specific hardware connection requirements. The hardware connection requirements necessitate various interconnections between computers, servers, routers and other physical equipment in order to implement the selected protocols and communications.

In order to provide the necessary connections, offices are now wired for computer network connections. Typically, cables run horizontally across a floor to interconnect the computers on that floor. Various networking equipment, such as routers, hubs and bridges, are located within a wiring closet on the floor. The networking equipment in the wiring closets on different floors are interconnected with vertically running cables. The horizontal cables typically terminate at a patch panel within the wiring closet. The networking equipment also terminate in a patch panel. To provide a specific

computer with a connection to the network, the appropriate locations within the patch panels are interconnected with patch cords.

When a user changes locations, the physical interconnections must also be changed to provide the user with access to the same network equipment. Frequent changes in workforce and work space has resulted in significant changes to networks. These changes require multiple accesses to the interconnections, and complicated interconnections. Such changes also increase the costs of maintaining a network and are likely to cause more frequent faults. Therefore, a need exists for a system which allows automated interconnections of computers and networks.

Several different systems have been proposed for automating connections in a wiring closet through the use of cross connect switches. However, each of these systems include protocol specific hardware for making the connections. Thus, if a single network is used, the computers can be easily rearranged; but if more than one network is part of the system, as in today's multi-protocol corporate data networks, automated changes in configurations are not possible. Plug-in cards (or equivalent hardware) of various types are used to interconnect the computers. Each plug-in card is designed for a specific communication protocol. When a computer is to be connected to a different network, the plug-in card for that computer has to be changed. Therefore, a need exists for an automated interconnection system which can operate with different protocols.

Summary of the Invention

The present invention in great part overcomes the deficiencies of existing interconnection systems by providing a cross-connect switch which is operable with different protocols. According to one aspect of the invention, each device is connected to the

interconnection system by programmable input/output (I/O) blocks. The I/O blocks include circuitry for executing different types of connections. Each I/O block has four differential pair inputs or outputs. The I/O block can use any set of these pairs, so as to accommodate different network protocols on different pairs.

According to another aspect of the invention, the I/O blocks provide for selective termination of each of the differential pairs. According to another aspect of the invention, the I/O blocks include circuitry to account for phantom current, half-duplex operation, and insertion losses.

According to another aspect of the invention, the I/O blocks are connected together through two crosspoint modules, one for transmission and one for reception. An output of each distribution side I/O block is connected to the transmit crosspoint module, and an input to the receive crosspoint module. The I/O blocks on the equipment side of the switch are connected to the crosspoint modules in reverse. Thus, by appropriately setting the connections in the cross point module, each computer on the distribution side can be connected to the appropriate network equipment on the equipment side. The crosspoint modules can be implemented as analog switches or digital routers, with sufficient bandwidth to accommodate different protocols.

Brief Description of the Drawings

Fig. 1 illustrates a computer system including the multi-protocol cross connect switch of the present invention.

Fig. 2 illustrates a physical embodiment of the present invention.

Fig. 3 is a block diagram illustrating an embodiment of the present invention.

Fig. 4 is a block diagram illustrating portions of an I/O block according to an embodiment of the present

invention.

Fig. 5 is a block diagram illustrating half duplex control in the present invention.

Figs. 6A and 6B are schematics illustrating token ring termination according to an embodiment of the present invention.

Detailed Description

Fig. 1 illustrates the connections in the computer system utilizing the multi-protocol cross connect switch of the present invention. A multi-protocol cross connect switch 10 is connected on a distribution side to a variety of computers 21-27. On an equipment side, the cross connect switch 10 is connected to different types of networking interfaces, such as Ethernet hubs 31, 33 or a token ring hub 34. The interconnection interfaces may be connected together or connected to other interfaces at different locations through an Ethernet bridge 32 or other types of bridges or routers 35. The cross connect switch operates to connect each of the computers 21-27 to one of the interconnection interfaces 31-35 so that the computer is operating on a network. A central management station 15 is connected to the cross connect switch 10 in order to control the connections within the cross connect switch.

Fig. 2 illustrates a physical embodiment of the present invention. As illustrated in Fig. 2, the cross connect switch 10 can be implemented as a set of cards which fit into an equipment rack. The rack can be designed to be installed in a standard 19 inch rack for interconnections with the networking interfaces. As illustrated in Fig. 2, the equipment rack can accommodate a variety of cards which implement the cross connect switch. Access cards 110 each include connections for up to 18 ports 121. The 19 inch rack can accommodate up to 6 distribution access cards and 6 equipment access cards. The access cards terminate four differential pairs on

each port 121. As discussed below, typically two pairs in each port are switched through the system. Two cross point modules 130, 135 implement a switching fabric of 108 x 108 x 2 pairs. A main controller card 140 controls the access and crosspoint module cards. The main controller card also is an interface to the system software. An optional test card 150 is used to test the cables attached to the system. It can measure cable length, noise and impedance, and find miswires, cut and shorted cable. This information can then be sent to the central management station 15 through the main controller card 140. The system operator is thereby alerted to the equipment problems.

Fig. 3 illustrates, in a block format, the components of the cross connect switch 10 according to an embodiment of the present invention. An input/output (I/O) block 210 is connected to each port 121 of the cross connect switch 10 for the distribution side. A second I/O block 220 is connected to each port on the equipment side. Two cross-point modules 230, 240 are used to interconnect the I/O blocks on the distribution side 210 and equipment side 220. The crosspoint modules can be analog switches or digital routers. According to a preferred embodiment, analog switches are used. Digital routing methods use techniques such as time division multiplexing on an internal master digital bus. Under the current state of the technology, digital routing has a number of drawbacks in a high speed multi-protocol environment. For example, bandwidths of several hundred gigahertz are required to be supported by the master digital bus if one is to support several tens of ports with protocols up to 125 megabits per second, such as TPDDI. Also, signal continuity and timing requirements of some protocols may not be met by time division multiplexing techniques. In particular, timing can be a problem when a random mixture of protocols operating at different speeds are cross connected.

Unacceptable delays between packets may be introduced. Analog routing does not have the same limitations because a dedicated physical connection is implemented between each input and associated output port.

The I/O blocks 210, 220 for each port may also include analog or digital circuitry. Appropriate A/D and D/A converters (not shown) are used for connecting to the ports and crosspoint modules as necessary. The cross connect switch 10 is controlled by commands 250 from the central management station 15. The central management station 15 includes a computer controller 17 and a terminal 16. Commands 250 are input into the transmit crosspoint module 230 and receive cross-point module 240 in order to select the specific ports to be interconnected. Commands are also input into the I/O blocks 210, 220 for pair selection, pair termination, and implementation of half duplex control. A set of terminators 211 is selectively connectable to each of the pairs on a port. The terminators can be selectively connected and disconnected from the pair. Termination is required when a system is at the receiving end of a connection. Connection switches 212 are used to connect one of the four differential wire pairs 215-218 to each transmit crosspoint module 230 and receive crosspoint module 240. Compensation amplifiers 213, 214 are used to overcome signal strength losses in the cross connect switch.

Fig. 4 illustrates in more detail the elements of the I/O block 210. The elements of the equipment side I/O block 220 would be identical. The I/O block includes four differential pair input or output connections 215-218. The differential pairs are connected to two sets of switches 321-324, 341-344. Many protocols operate with only two differential pairs, one for transmission and one for reception. Reception switches 321-324 are used to select one of the differential pairs 215-218 as an input to the cross connect switch. Commands 250 from the

computer controller 17 are used to selectively operate a single switch to connect one of the differential pairs 215-218 to the input line 320 of the I/O block. Similarly, commands from the computer controller 17 are used to selectively operate one of the transmission switches 341-344 to connect one of the differential pairs 215-218 to the transmission line 340 of the I/O block. The reception line 320 and transmission line 340 are selectively connected by switches 371, 372 to input and output ports 381, 382 of the cross-point modules. As noted previously, compensation amplifiers 213, 214 are used to compensate for signal losses in the I/O block. An antenuator 350 is also connected to the reception line in order to equalize signal amplitudes. Auxiliary amplifiers 331-334 can be used to further compensate for losses on the appropriate output selected pair. Terminators 311-314 are selectively connectable to each of the differential pairs 215-218 by commands from the computer controller 17. The reception differential pair can then be selectively terminated as needed. Similarly, the input 382 from the crosspoint modules can be selectively terminated by terminator 375 as needed.

Fig. 4 also illustrates circuitry for implementation of half duplex control. Half duplex protocol uses only one differential pair to communicate. The transmit and receive direction is switched on the single pair as required to accommodate the communications. When there is no communication, the selected port is configured as an input. Thus, the distribution I/O block 210 and the equipment I/O block 220 would both have a port configured as an input. When a communication packet is received at one I/O block, the other I/O block must be reconfigured as an output. When the communication packet is completed, both of the I/O blocks return their ports to input configurations. The port configuration is controlled by a half duplex controller 360 and two line monitors 364, 366. Line monitor 364 is connected to the

reception line 320 when a line monitor 364 detects an incoming signal, and indicates the signal to the half duplex controller. A second line monitor 366 monitors the transmission line to determine whether a signal has been received from the cross-point module. When a signal is received from the cross-point module the line monitor indicates this receive signal to the half duplex controller 360. The half duplex controller then operates to control the transmission amplifier 331, the reception connection switch 321, and the terminator 311. Upon receipt of a transmission, indicated by line monitor 366, the amplifier 331 is enabled, the terminator 311 is disabled and reception connection switch 321 is disabled. When the transmission ends, the terminator is enabled and the reception switch is again enabled to monitor for receive signals.

Fig. 5 illustrates in greater detail the connections of the half duplex controller 360. The line monitors 364, 366 have inputs for user memory map bits representing a threshold. The line monitor compares the input signal with the threshold to determine whether a signal is being received. An output from the line monitor goes to the half duplex controller 360. The half duplex controller then controls the receive switch 321, sense switch 341, and termination switch 311. The termination switch 311 selectively connects and disconnects the input line from a resistor 315 to ground.

Protocols such as token ring require the generation of a DC phantom current flowing into the pairs being used for interconnection in order to have the connection inserting into the ring. In order to accommodate token ring type protocols, a token ring interface 400 is connected to the pairs of the relevant ports, as illustrated in Fig. 4. The interface detects the presence of a phantom current on the distribution side and regenerates it on the equipment side, and vice versa. When a fault exists on one side, it is detected by the

circuit and relayed through the cross point switch to the other side. Some analog cross connect switch technologies cannot accommodate large DC currents present on wire pairs as required by some protocols. Couplings across the cross connect switch must be AC and the phantom DC currents have to be relayed by other mechanisms.

Figs. 6A and 6B are schematics of the token ring interface with respect to the equipment side and distribution side, respectively, of the cross connect matrix. These figures also illustrate the connections at the trunk coupling unit and the computer station. However, these portions of the figures are not part of the cross connect switch, but are part of the system into which the cross connect switch is placed. As illustrated in Fig. 6A, on the equipment side, the phantom current must be detected at the receive port. The differential pair of the receive port are connected together by two resistors 415, 417, each having a typical value of 2K ohms (± 1%). A resistor, having a value of approximately 50 ohms, and a capacitor, having a value of approximately 0.1μF, are connected in parallel from the center point of the two resistors to the midrail 401. The phantom current is detected at the center point of the two resistors 415, 417. On the transmit port, a phantom current supply 402, having a reference of the midrail 401, is selectively connected to the two wires of the transmit pair through resistors 405, 406. The selective connection is made from a signal through resistor 411 to connect the transistor 412 to the reference voltage VEE. When the transistor 412 is turned on, the voltage VEE is connected is through resistor 404 to the base of transistor 403 to connect the phantom current voltage supply 402 to the transmitting port. Resistors 405 and 406 typically have values of 2K ohms. Resistors 411 and 404 typically have values of 10K ohms. Each of the wires on the pair also includes a current limiting resistance

407, 409, 413, 419, and a filtering capacitor 408, 410, 414, 420. The current limiting resistance has a typical value of 2.7 ohms. The filtering capacitances typically have a value of 0.1 μF.

As illustrated in Fig. 6B, the token ring interface on the distribution side operates to detect the phantom current generated by the station. The midrail and the phantom current detector line are connected together through resistance and capacitance 460, 461.

The present invention has the capability of operating with a variety of different protocols. Table 1 illustrates different protocols, the speeds at which they operate, and the ports used for transmission and reception.

Protocol	Speed (Mbps)	TX pair	RX pair	special circuit	DC
ISDN S/T	0.192	2	1	pair selection, DC blocking	-48V
AS-400	1	1	1	pair selection, dynamic termination and amplifier switching	-
T1	1.544	3	2	pair selection	-
IBM 3270	2.358	1	1	pair selection, dynamic termination and amplifier switching	-
Token-ring	4/16	2	1	pair selection, phantom current detect and generate, fault detect and generate	7V
Ethernet	10	3	2	pair selection	-
ATM-25	25.6	2 or 3	1 or 4	pair selection	-
T3	44.736	3	4	pair selection	-
TP-DDI	100	3	4	pair selection, high bandwidth	-
Fast-Ethernet	100	3	2	pair selection, high bandwidth	-
RS-422	0-0.1	3	4	pair selection	-
RS-232	0-0.1	3	4	pair selection	-
baseband video	0-6MHz	3	4	pair selection	-

Table 1

Using the central management station 15, commands are sent from the computer controller 17 to the different I/O blocks in order to indicate the type of protocol to be implemented in that I/O block. Based upon the protocol to be implemented, the I/O block operates in different manners in order to provide the proper functions for the protocol. Indicated in Table 1 are the circuit switch function for each protocol. For all the protocols, the appropriate differential pairs are selected using the switching mechanisms 212, 222. For certain types of protocol, the termination is dynamically controlled using terminators 211, 221. With respect to token ring protocols, as discussed above, a phantom current detection and generation is performed, as well as fault detection and generation. As indicated in Table 1, the various communication protocols operate over different bandwidths. It is important to warrant 0 DB insertion loss over a bandwidth which covers all of the protocols of interest. If the I/O blocks or a cross point modules introduced some amount of insertion loss inside the frequency range of a protocol, it is necessary to compensate for this loss. Wide bandwidth amplifiers are used to overcome the insertion loss.

In addition to selecting the protocols for each I/O block, the central management station 15 also controls the receive cross point module 240 and transmit cross point module 230 in order to connect together appropriate I/O blocks on the distribution side and equipment side of the cross connect switch. The cross connect switch of the present invention allows different protocols to be used simultaneously through the switch without the need of specialized circuitry. Thus, for each port, different protocols can be used based upon the equipment being connected to. Since the protocols and the equipment can be controlled from the central management station, physical changes for interconnecting equipment or

changing protocols are not required.

Having thus described the embodiments of the invention, various alterations, modifications, and improvements will readily occur to those skilled in the art. Such alterations, modifications, and improvements are intended to be part of this disclosure, and are intended to be within the spirit and scope of the invention. Accordingly, the foregoing description is by way of example only and is not intended as limiting. The invention is limited only as defined in the following claims and the equivalents thereto.

CLAIMS

1. A computer network comprising:

a plurality of computer devices each having a local area network interface means for digital communication with other one of said devices according to one of a plurality of protocols;

a plurality of local area network hubs;

a multi-protocol cross-connect switch for automatically providing a signal path between each of said computer devices and one of said hubs under control of a controller command signal;

a plurality of multi-protocol data transmission cables extending between locations for said devices and said cross-connect switch; and

a central management controller for generating said command signal.

2. The network as claimed in claim 1, wherein said cross-connect switch includes a plurality of input/output blocks.

3. The network as claimed in claim 2, wherein said input/output blocks have a plurality of different protocol configurations settable by said central management controller.

4. The network as claimed in claim 1, 2 or 3, wherein said switch is an analog switch.

5. A network interconnection apparatus comprising:

at least one cross connect module having a plurality of inputs and a plurality of outputs, the cross connect module selectively connecting inputs to outputs; and

a plurality of input/output blocks connected to the inputs and outputs of the cross connect module.

6. The network interconnection apparatus as

claimed in claim 5, wherein each input/output block comprises:

a block output connected to one of the inputs of the cross connect module;

a block input connected to one of the outputs of the cross connect module;

at least one port connected to a corresponding device in the network; and

a connection circuit for selectively connecting the block output and block input to the at least one port.

7. The network interconnection apparatus of claim 6, wherein the at least one port includes at least three ports, and wherein the connection circuit selectively connects one of the at least three ports to the block input, and another one of the at least three ports to the block output.

8. The network interconnection apparatus of claim 6, further comprising a control circuit, and wherein the connection circuit selectively connects the at least one port and the block input and block output based upon input signals from the control circuit.

9. The network interconnection apparatus of claim 8, wherein the inputs and outputs of the cross connect module are selectively connected based upon a signal from the control circuit.

10. The network interconnection apparatus of claim 6, wherein the connection circuit includes a bi-directional switch matrix.

11. The network interconnection apparatus of claim 6, wherein each of the input/output blocks further includes:

a termination module for selectively terminating the

at least one port into an appropriate impedance.

12. The network interconnection apparatus of claim 11, wherein the termination module selectively terminates the at least one port when the at least one port is connected to the block output.

13. The network interconnection apparatus of claim 6, wherein each of the input/output blocks further includes:

at least one compensation amplifier, connected between the at least one port and one of the block input and block output, to account for signal attenuation.

14. The network interconnection apparatus of claim 6, wherein the input/output blocks include signal connection circuitry required by each of a plurality of communication protocols.

15. The network interconnection apparatus of claim 6, wherein the input/output block further includes half duplex control circuitry for selectively connecting a single port to the block input and block output to provide bi-directional communication through the single port.

16. The network interconnection apparatus of claim 15, wherein the half duplex control circuitry includes:

a line monitor for monitoring the block input to detect a signal received from the cross connect module;

a switch for connecting the block input to the single port when a signal is detected by the line monitor; and

a switch for connecting the block output to the single port when a signal is not detected.

17. The network interconnection apparatus of claim

16, wherein the half duplex control circuitry includes a termination connector for connecting the single port to a termination impedance when the signal is not detected.

18. The network interconnection apparatus of claim 16, wherein the half duplex control circuitry includes a second line monitor for monitoring the single port to detect a signal received from the single port.

19. The network interconnection apparatus of claim 6, wherein the at least one port on each of two input/output blocks connected through the cross connect module includes two ports, and the apparatus further comprises:

a phantom current detector connected to one of the ports of one of the input/output blocks for detecting a first phantom current;

a phantom current generator connected to one of the ports of the other of the input/output blocks for generating a second phantom current when the first phantom current is detected.

20. The network interconnection apparatus of claim 19, further comprising:

means for transmitting detection of the first phantom current from the one input/output block to the other input/output block through the cross connect module.

21. The network interconnection apparatus of claim 19, further comprising:

means for detecting a line fault on the port of the one input/output block; and

means for simulating a line fault on the port of the other input/output block.

22. The network interconnection apparatus of claim

6, wherein the cross connect module includes a plurality of analog cross connect switches.

23. The network interconnection apparatus of claim 22, wherein each of the input/output blocks includes at least one A/D converter connected to the at least one port.

24. The network interconnection apparatus of claim 6, wherein the cross connect module includes a plurality digital routing switches.

25. The network interconnection apparatus of claim 24, wherein each of the input/output blocks includes at least one A/D converter and at least one D/A converter connected to the at least one port.

26. The network interconnection apparatus as claimed in claim 5, wherein each input/output block includes:

at least one port for transmitting signals from the cross connect module and receiving signals to be transferred to the cross connect module; and

a protocol operation circuit, receiving a protocol selection signal indicating one of a plurality of protocols, for transmitting and receiving signals through the at least one port according to the protocol indicated by the protocol selection signal.

27. The network interconnection apparatus of claim 26, wherein the protocol operation circuit includes a termination circuit for selectively terminating the at least one port based upon the protocol selection signal.

28. The network interconnection apparatus of claim 26, the at least one port includes a plurality of ports,

and wherein the protocol operation circuit includes port selection circuits for selecting at least one of the plurality of ports for receiving signals and transmitting signals.

29. The network interconnection apparatus of claim 26, wherein the protocol operation circuit includes means for selectively transmitting signals and receiving signals through a single port at different times.

30. The network interconnection apparatus of claim 26, wherein the protocol operation circuit includes:

a phantom current detection circuit for detecting a phantom current based upon the protocol selection signal and generating a phantom current detection signal; and

a phantom current generator circuit for generating a phantom current based upon a protocol selection signal and a phantom current detection signal.

31. A method of configuring and managing a local area network comprising the steps of:

providing a multi-protocol cross-connect switch;

installing a plurality of multi-protocol data transmission cables extending between locations for computing devices in a building and said cross-connect switch, said computing devices operating according to one of a plurality of protocols;

connecting a plurality of local area network hubs each operating according to one of a plurality of protocols to said cross-connect switch;

causing said switch to connect each one of said computing devices to a selected one of said hubs;

relocating at least one of said computing devices to a different one of said locations; and

commanding said switch to connect said at least one of said computing devices relocated to said selected one of said hubs.

32. The method as claimed in claim 31, wherein said hubs are interconnected by at least one of a bridge and a router.

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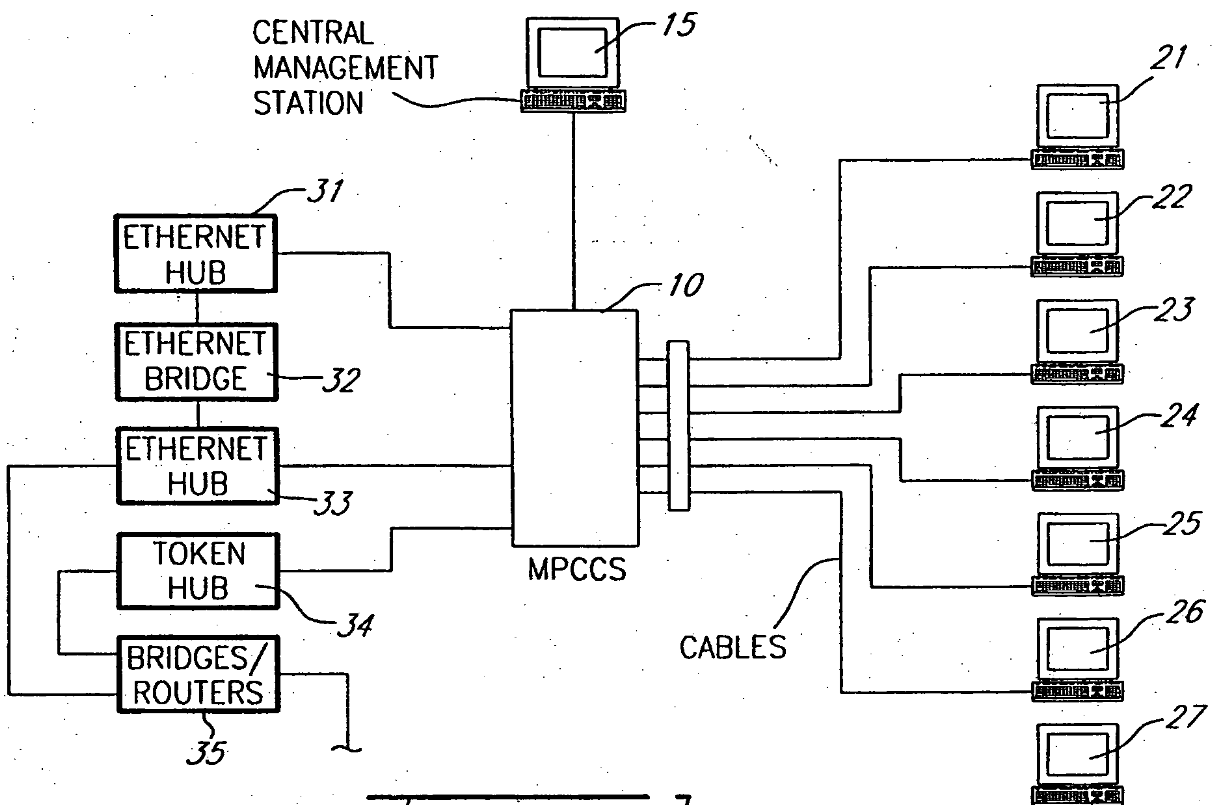
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15
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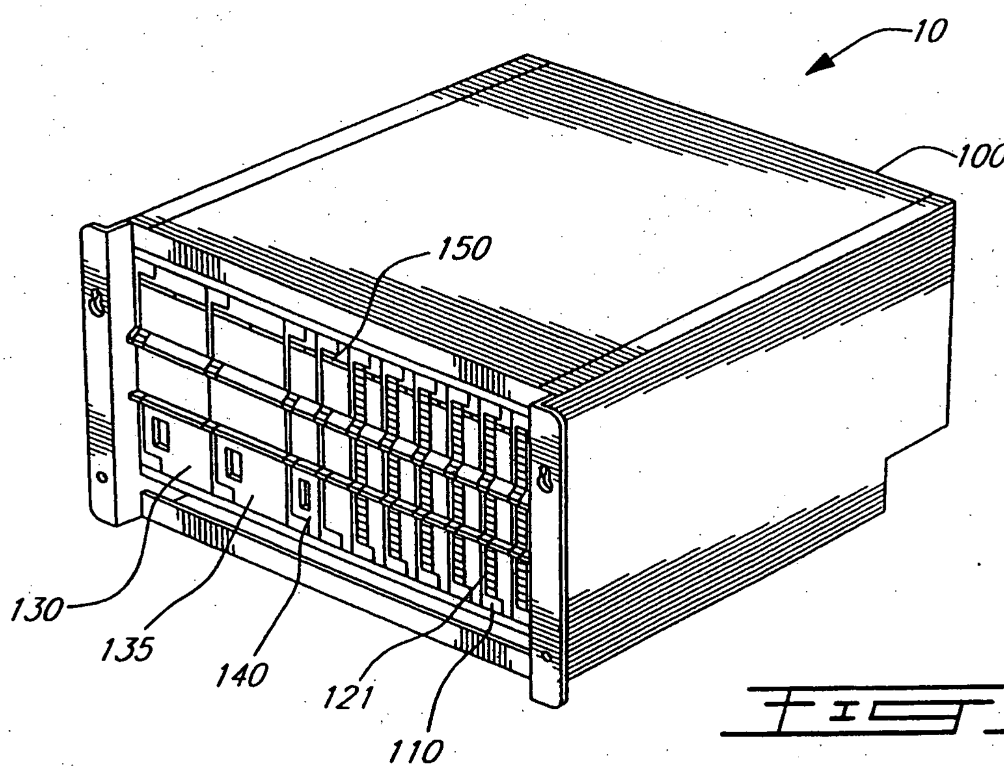
22
23
24
25
26
27
31
ETHERNET HUB
ETHERNET BRIDGE
32
ETHERNET HUB
33
TOKEN HUB
34
BRIDGES/ ROUTERS
35
10
MPCCS
CABLES

FIG. 1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140
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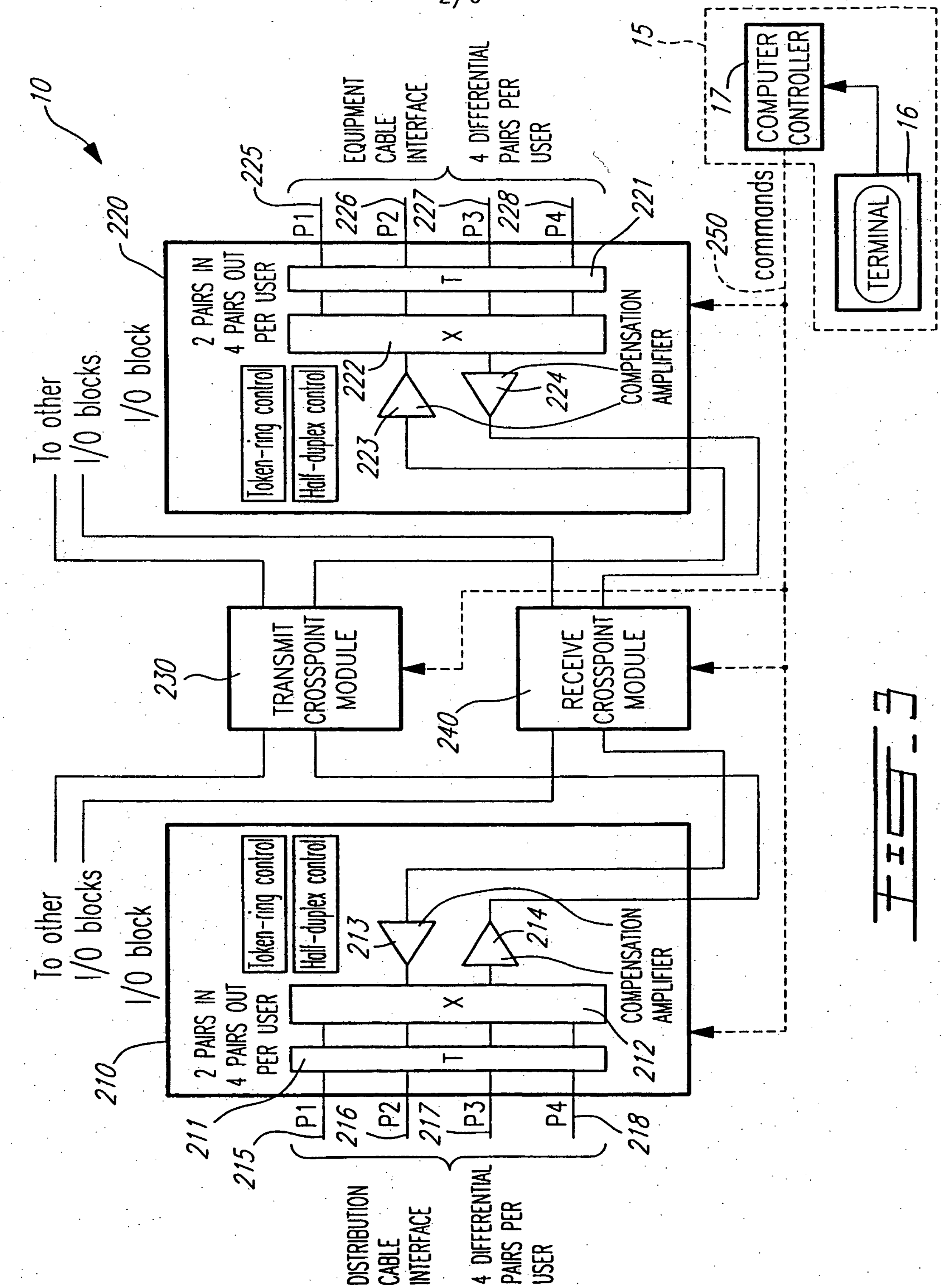
110

FIG. 2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16
TERMINAL
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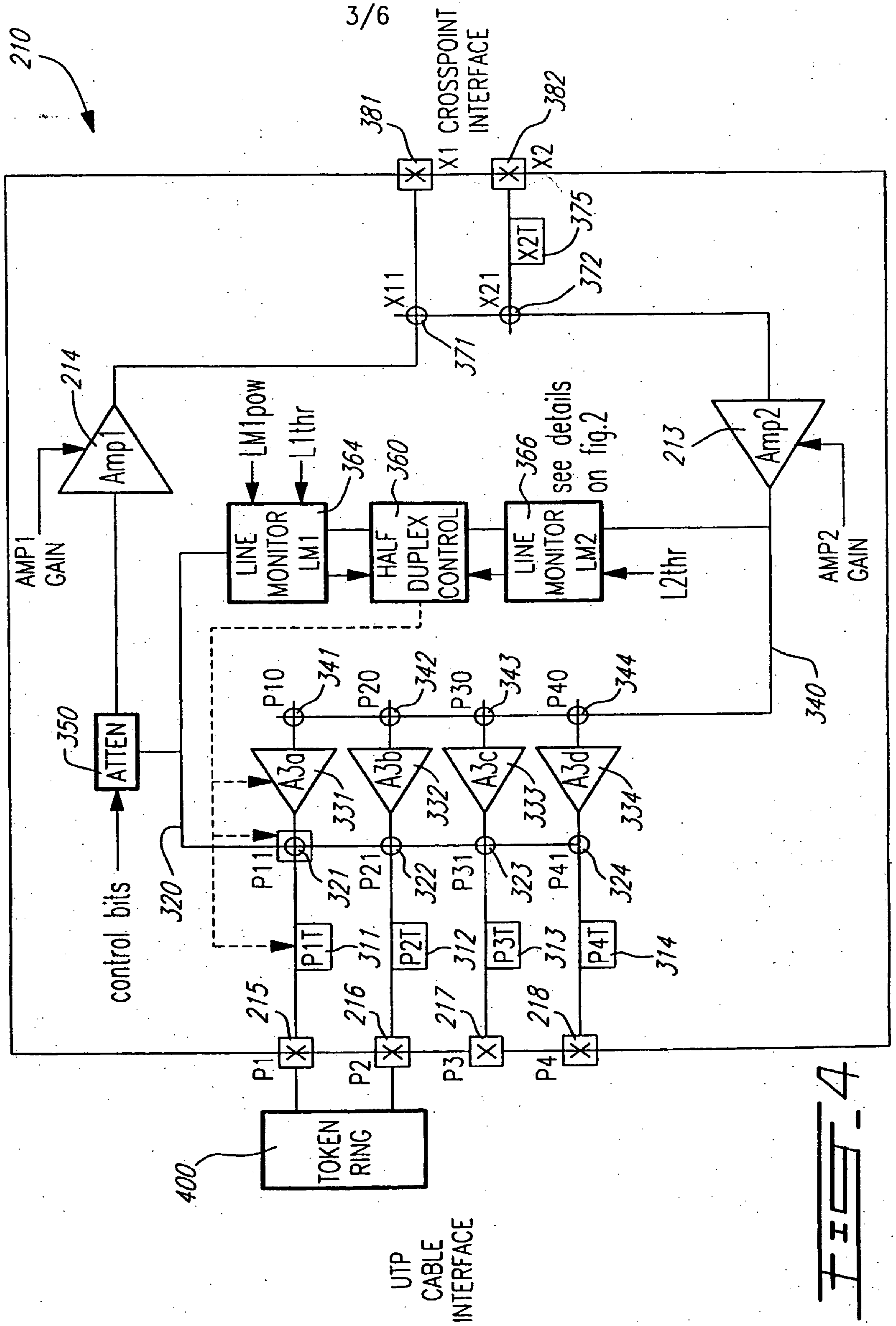
227
228
P1
P2
P3
P4
220
221
2 PAIRS IN 4 PAIRS OUT PER USER
T
X
Token-ring control
Half-duplex control
222
223
224
COMPENSATION AMPLIFIER
I/O block
To other I/O blocks
TRANSMIT CROSSPOINT MODULE
230
RECEIVE CROSSPOINT MODULE
240
To other I/O blocks
I/O block
Token-ring control
Half-duplex control
213
214
COMPENSATION AMPLIFIER
2 PAIRS IN 4 PAIRS OUT PER USER
X
T
210
211
212
P1
P2
P3
P4
215
216
217
218
DISTRIBUTION CABLE INTERFACE
4 DIFFERENTIAL PAIRS PER USER

FIG. 3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381
X1 CROSSPOINT INTERFACE
382
X2
375
X2T
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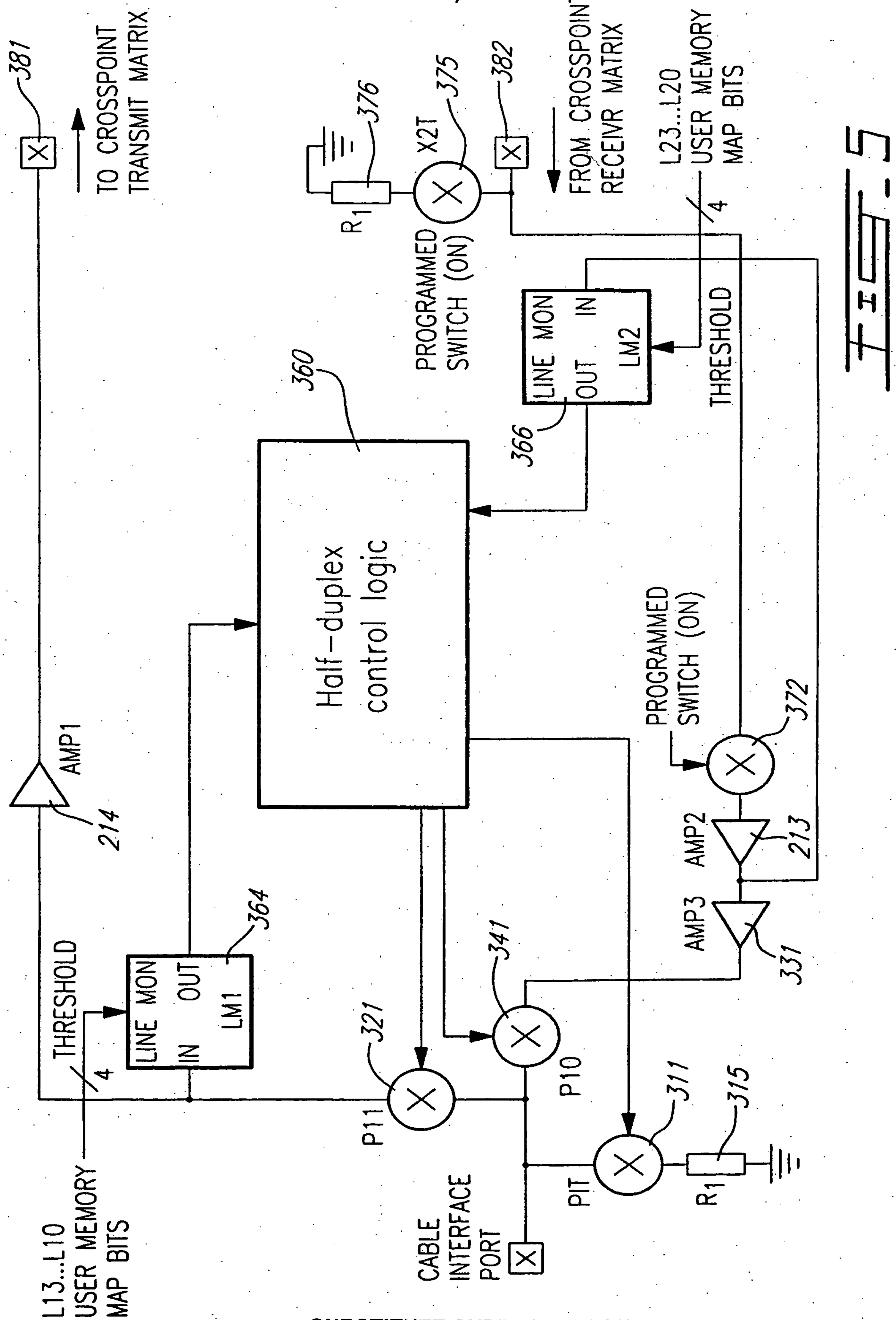
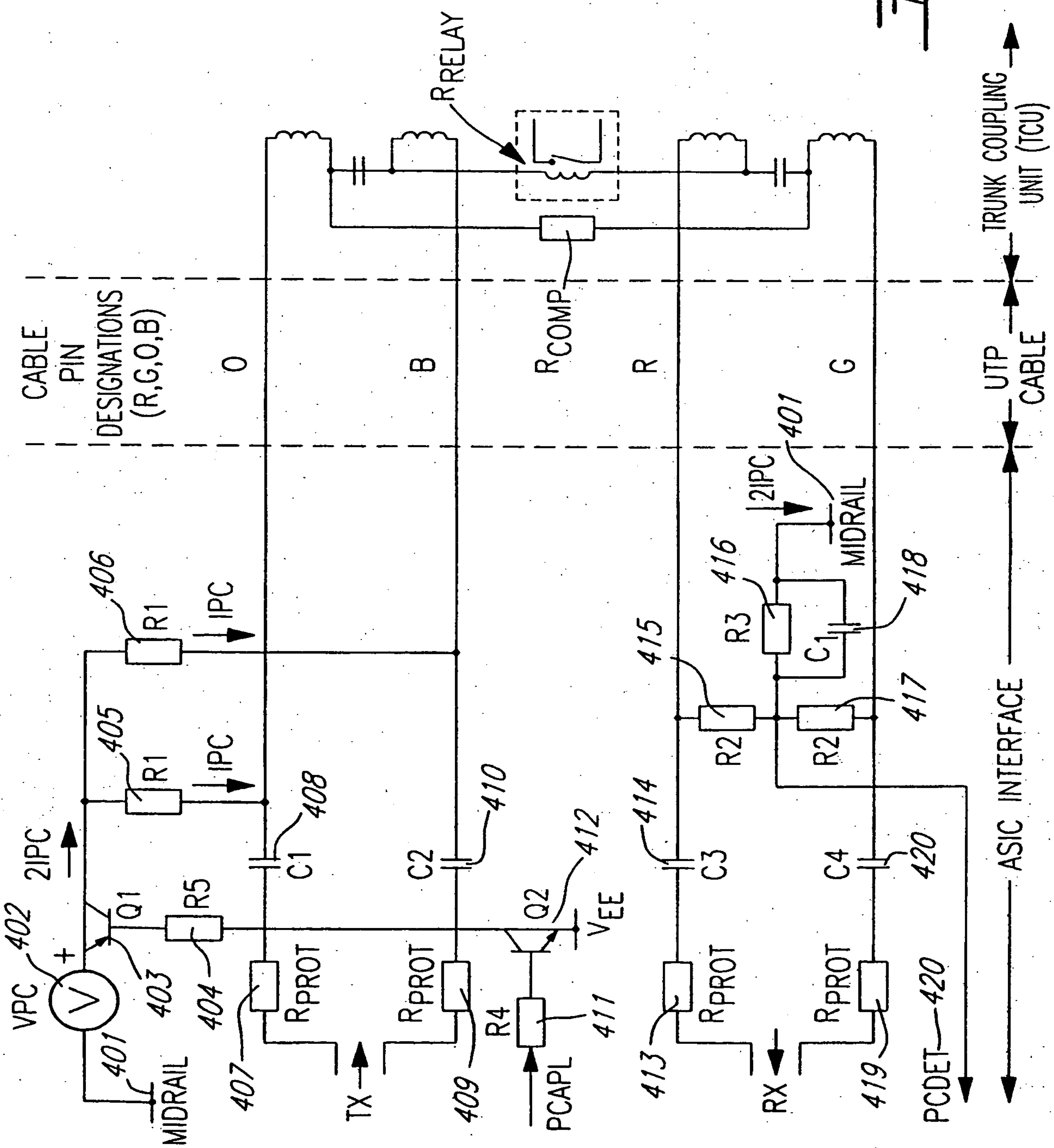
X21
X11
371
214
Amp1
AMP1 GAIN
LM1pow
L1thr
364
360
366
see details on fig.2
213
Amp2
AMP2 GAIN
LINE MONITOR LM1
HALF DUPLEX CONTROL
LINE MONITOR LM2
L2thr
340
P10
341
P20
342
P30
343
P40
344
350
ATTEN
A3a
A3b
A3c
A3d
331
332
333
334
control bits
320
P11
321
P21
322
P31
323
P41
324
P1T
311
P2T
312
P3T
313
P4T
314
215
216
217
218
P1
P2
P3
P4
400
TOKEN RING
UTP CABLE INTERFACE

FIG. 4



381
TO CROSSPOINT TRANSMIT MATRIX
376
375
382
R1
X2T
PROGRAMMED SWITCH (ON)
FROM CROSSPOINT RECEIVR MATRIX
L23...L20 USER MEMORY MAP BITS
4
LINE MON
IN
OUT
LM2
THRESHOLD
360
366
Half-duplex control logic
AMP1
214
PROGRAMMED SWITCH (ON)
372
AMP2
213
AMP3
331
THRESHOLD
LINE MON
IN
OUT
LM1
364
341
321
P10
P11
311
315
R1
PIT
L13...L10 USER MEMORY MAP BITS
CABLE INTERFACE PORT

FIG. 5



VPC
402
+
401
MIDRAIL
403
Q1
R5
404
2IPC
R1
405
IPC
406
R1
IPC
408
C1
407
RPROT
TX
409
RPROT
C2
410
Q2
412
VEE
R4
411
PCAPL
CABLE PIN DESIGNATIONS (R,G,O,B)
O
B
R
G
RRELAY
RCOMP
414
C3
413
RPROT
RX
415
R2
R3
416
C1
418
417
R2
2IPC
401
MIDRAIL
C4
420
419
RPROT
420
PCDET
ASIC INTERFACE
UTP CABLE
TRUNK COUPLING UNIT (TCU)

FIG. 6A

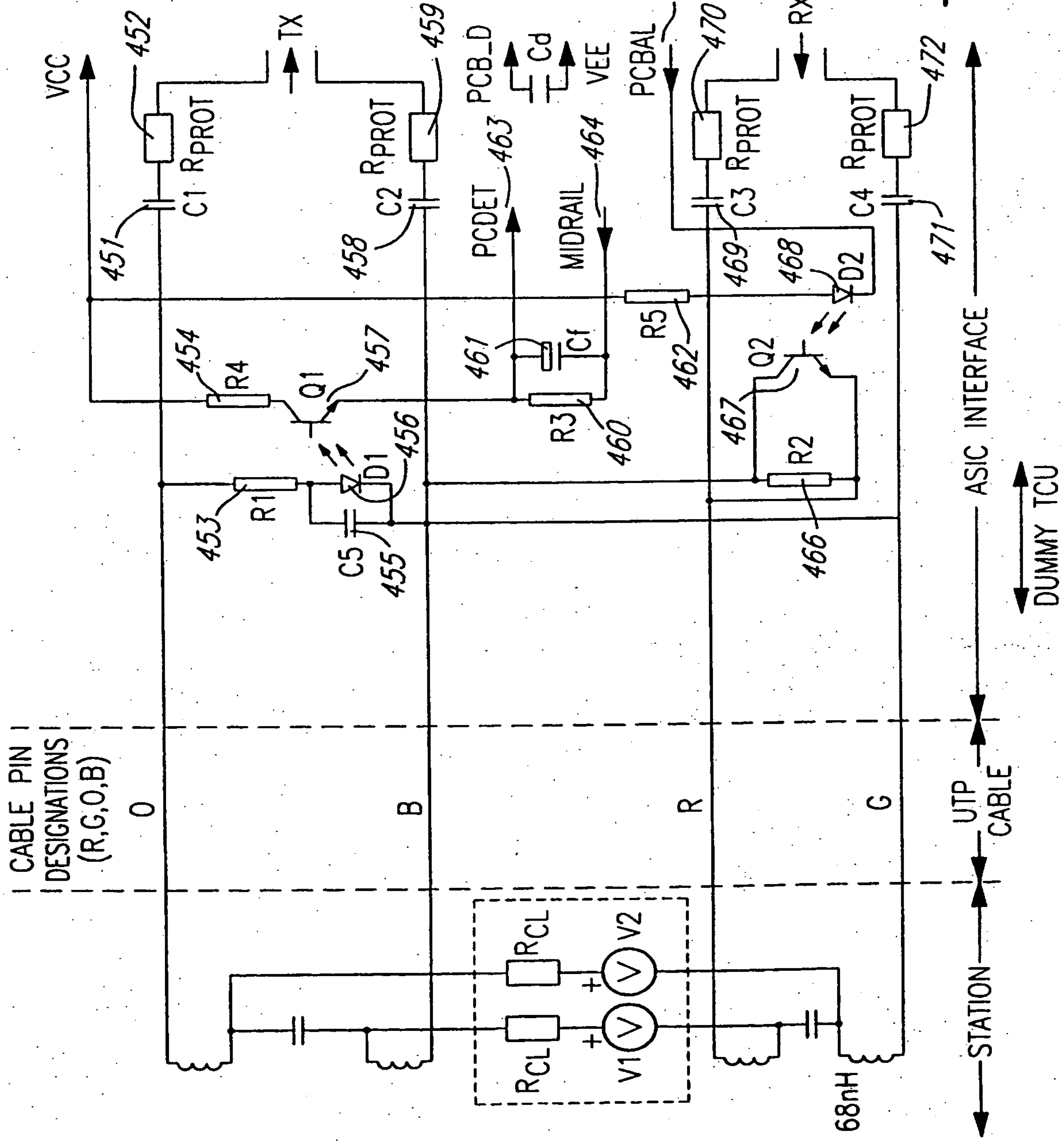

VCC
TX
PCB_D
Cd
VEE
PCBAL
RX
452
459
463
464
465
470
472
R_{PROT}
C1
C2
C3
C4
451
458
469
471
PCDET
MIDRAIL
468
D2
R5
462
461
Cf
R4
454
Q1
457
R3
460
Q2
467
R2
466
R1
453
D1
456
C5
455
ASIC INTERFACE
DUMMY TCU
CABLE PIN DESIGNATIONS (R,G,O,B)
O
B
R
G
UTP CABLE
R_{CL}
V1
V2
STATION
68nH

FIG. 6B

INTERNATIONAL SEARCH REPORT

Interi nal Application No
PCT/CA 97/00985

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H04L12/44 H04L29/06 H04Q1/14

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H04L H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 624 043 A (WHITAKER CORP) 9 November 1994	1-6, 10-13, 22,24, 31,32
	see page 2, column 1, line 1 - page 3, column 2, line 39	
Y	see page 3, column 4, line 56 - page 4, column 5, line 47	7-9, 14-21, 26-29
	see page 5, column 8, line 19 - page 6, column 9, line 28 see figures 1,2,4-6 ---	
Y	US 5 574 722 A (SLYKHOUSE TOM ET AL) 12 November 1996 see column 1, line 1 - column 2, line 61 see column 3, line 30 - column 4, line 3 see column 4, line 60 - column 7, line 14 ---	7-9,14, 26-29
	-/--	

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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1

Date of the actual completion of the international search	Date of mailing of the international search report
14 April 1998	21/04/1998
Name and mailing address of the ISA European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Authorized officer Karavassilis, N

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
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A	see page 4, line 17 - page 5, line 37; claims 1-7	30
Y	GB 2 280 573 A (NORTHERN TELECOM LTD) 1 February 1995 see page 1, line 1 - page 2, line 10 see page 2, line 29 - page 5, line 12	15-18
A	GB 2 300 330 A (NORTHERN TELECOM LTD) 30 October 1996 see page 1, line 23 - page 2, line 11 see page 3, line 33 - page 4, line 13 see page 5, line 24 - line 31	13
A	US 5 274 631 A (BHARDWAJ VINOD K) 28 December 1993 see column 4, line 21 - column 8, line 30	24
A	SAUNDERS S: "BEST OF BOTH WORLDS FOR HUBS AND SWITCHES" DATA COMMUNICATIONS, vol. 23, no. 14, October 1994, page 37/38 XP000469937 see the whole document	32
A	US 4 849 977 A (BAUN JR PHILIP J ET AL) 18 July 1989 see column 7, line 27 - column 8, line 9 see abstract	23,25

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/CA 97/00985

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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A1

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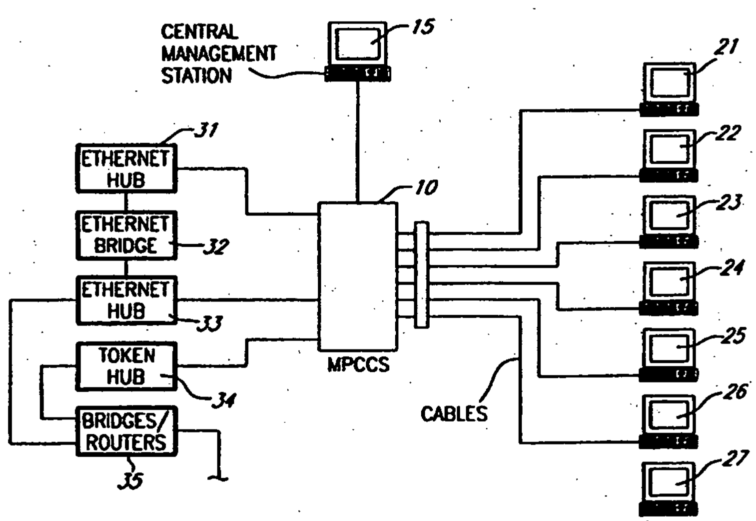
(81) Designated States: AU, CA, CN, JP, MX, SG, European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
With international search report.
With amended claims.

Date of publication of the amended claims:
6 August 1998 (06.08.98)

(54) Title: NETWORK INCLUDING MULTI-PROTOCOL CROSS-CONNECT SWITCH



(57) Abstract

The present invention relates to a cross-connect switch which allows different protocols to be used. The switch is made up of two cross point modules, one for transmission and one for reception. I/O blocks corresponding to each station or network interface are connected to the cross point modules. Each I/O block includes four differential pairs. The I/O block permits selective activation for transmission or reception of any of the four pairs. In addition, half duplex control logic is used to implement protocols using a single differential pair for both transmission and reception. Also a token ring interface is included on the I/O blocks in order to allow detection and generation of phantom DC currents necessary for operation with token rings.

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AMENDED CLAIMS

[received by the International Bureau on 19 June 1998 (19.06.98); original claims 1-32 replaced by new claims 1-33 (6 pages)]

1. A computer network including a plurality of devices each having a local area network interface which can communicate digitally with another one of the plurality of devices using one of a plurality of protocols, through one of a plurality of local area network hubs, the computer network CHARACTERIZED BY:

a multi-protocol cross-connect switch having a plurality of input/output blocks, each of whose configuration can be changed by a configuration signal from communicating using one of the plurality of protocols to communicating using another of the plurality of protocols, the switch automatically providing a signal path between one of the plurality of devices and one of the local area network hubs responsive to a command signal;

a plurality of multi-protocol data transmission cables connecting the local area network interface of each device to an input/output block; and

a central management controller having an output connected to the switch, the output carrying the configuration signal and the command signal.

2. The network as claimed in claim 1, wherein said cross-connect switch includes a plurality of input/output blocks.

3. The network as claimed in claim 2, wherein said input/output blocks have a plurality of different protocol configurations settable by said central management controller.

4. The network as claimed in claim 1, 2 or 3, wherein said switch is an analog switch.

5. A network interconnection apparatus comprising:

a multi-protocol cross-connect switch having a plurality of inputs and a plurality of outputs, wherein the cross-connect switch can selectively connect inputs to outputs; and

a plurality of input/output blocks which can be configured to communicate using any one of a plurality of protocols, the input/output blocks connected to the inputs and outputs of the switch.

6. The network interconnection apparatus as claimed in claim 5, wherein each input/output block comprises:

a block output connected to one of the inputs of the cross connect module;

a block input connected to one of the outputs of the cross connect module;

at least one port connected to a corresponding device in the network; and

a connection circuit for selectively connecting the block output and block input to the at least one port.

7. The network interconnection apparatus of claim 6, wherein the at least one port includes at least three ports, and wherein the connection circuit selectively connects one of the at least three ports to the block input, and another one of the at least three ports to the block output.

8. The network interconnection apparatus of claim 6, further comprising a control circuit, and wherein the connection circuit selectively connects the at least one port and the block input and block output based upon input signals from the control circuit.

9. The network interconnection apparatus of claim 8, wherein the inputs and outputs of the cross connect module are selectively connected based upon a signal from the control circuit.

10. The network interconnection apparatus of claim 6, wherein the connection circuit includes a bi-directional switch matrix.

11. The network interconnection apparatus of claim 6, wherein each of the input/output blocks further includes:

a termination module for selectively terminating the at least one port into an appropriate impedance.

12. The network interconnection apparatus of claim 11, wherein the termination module selectively terminates the at least one port when the at least one port is connected to the block output.

13. The network interconnection apparatus of claim 6, wherein each of the input/output blocks further includes:

at least one compensation amplifier, connected between the at least one port and one of the block input and block output, to account for signal attenuation.

14. The network interconnection apparatus of claim 6, wherein the input/output blocks include signal connection circuitry required by each of a plurality of communication protocols.

15. The network interconnection apparatus of claim 6, wherein the input/output block further includes half duplex control circuitry for selectively connecting a single port to the block input and block output to provide bi-directional communication through the single port.

16. The network interconnection apparatus of claim 15, wherein the half duplex control circuitry includes:

a line monitor for monitoring the block input to detect a signal received from the cross connect module;

a switch for connecting the block input to the single port when a signal is detected by the line monitor; and

a switch for connecting the block output to the single port when a signal is not detected.

17. The network interconnection apparatus of claim 16, wherein the half duplex control circuitry includes a termination connector for connecting the single port to a termination impedance when the signal is not detected.

18. The network interconnection apparatus of claim 16, wherein the half duplex control circuitry includes a second line monitor for monitoring the single port to detect a signal received from the single port.

19. The network interconnection apparatus of claim 6, wherein the at least one port on each of two input/output blocks connected through the cross connect module includes two ports, and the apparatus further comprises:

a phantom current detector connected to one of the ports of one of the input/output blocks for detecting a first phantom current;

a phantom current generator connected to one of the ports of the other of the input/output blocks for generating a second phantom current when the first phantom current is detected.

20. The network interconnection apparatus of claim 19, further comprising:

means for transmitting detection of the first phantom current from the one input/output block to the other input/output block through the cross connect module.

21. The network interconnection apparatus of claim 19, further comprising:

means for detecting a line fault on the port of the one input/output block; and

means for simulating a line fault on the port of the other input/output block.

22. The network interconnection apparatus of claim 6, wherein the cross connect module includes a plurality of analog cross connect switches.

23. The network interconnection apparatus of claim 22, wherein each of the input/output blocks includes at least one A/D converter connected to the at least one port.

24. The network interconnection apparatus of claim 6, wherein the cross connect module includes a plurality digital routing switches.

25. The network interconnection apparatus of claim 24, wherein each of the input/output blocks includes at least one A/D converter and at least one D/A converter connected to the at least one port.

26. The network interconnection apparatus as claimed in claim 5, wherein each input/output block includes:

at least one port for transmitting signals from the cross connect module and receiving signals to be transferred to the cross connect module; and

a protocol operation circuit, receiving a protocol selection signal indicating one of a plurality of protocols, for transmitting and receiving signals through the at least one port

according to the protocol indicated by the protocol selection signal.

27. The network interconnection apparatus of claim 26, wherein the protocol operation circuit includes a termination circuit for selectively terminating the at least one port based upon the protocol selection signal.

28. The network interconnection apparatus of claim 26, the at least one port includes a plurality of ports, and wherein the protocol operation circuit includes port selection circuits for selecting at least one of the plurality of ports for receiving signals and transmitting signals.

29. The network interconnection apparatus of claim 26, wherein the protocol operation circuit includes means for selectively transmitting signals and receiving signals through a single port at different times.

30. The network interconnection apparatus of claim 26, wherein the protocol operating circuit includes:

a phantom current detection circuit for detecting a phantom current based upon the protocol selection signal and generating a phantom current detection signal; and

a phantom current generator circuit for generating a phantom current based upon a protocol selection signal and a phantom current detection signal.

31. A method of configuring and managing a computer network, comprising steps of:

connecting at least one computing device through a multi-protocol cable to a multi-protocol cross-connect switch;

connecting a least one local area network hub through a multi-protocol cable to the switch;

changing a protocol used by the switch to communicate with the computing device or the local area network hub from an unselected one of a plurality of protocols to a selected one of the plurality of protocols; and

connecting the computing device to the local area network hub through the switch using the selected protocol.

32. The method of claim 31, further comprising steps of:

relocating a computing device to a new location;

connecting the relocated computing device through another multi-protocol cable to the switch; and

commanding the switch to reconnect the computing device to the local area network hub through the switch using the selected protocol.

33. The method as claimed in claim 31, wherein said hubs are interconnected by at least one of a bridge and a router.